



Aalto University
School of Business

Optimizing network characteristics for sustainable network effects in multi-sided platforms

Bachelor's Thesis
Joni Pakarinen
1.1.2018
Information and Service Management



Author Joni Pakarinen

Title of thesis Optimizing network characteristics for sustainable network effects in multi-sided platforms

Degree Bachelor of Science in Economics and Business Administration

Degree programme Information and Service Management

Thesis advisor(s) Niina Mallat and Jani Merikivi

Year of approval 2018

Number of pages 27

Language English

Abstract

Large network size has been seen as the main reason behind networks' success in the past in terms of value creation and making different types of interactions possible. This paradigm has been challenged, however, by some of the recent studies as some sizeable networked platforms, e.g., MySpace and Orkut, have seen their end even after being the market leader in terms of the network size.

This paper questions the network size as the sole determinant of networks' success. It explores several important characteristics of a network in addition to its size, e.g., structure, roles, groups and conduct, which advance users' possibilities for value capturing. The comprehensive literature review in studies on strategic management, management science, information systems science, sociology and economics done in this thesis proposes that considering aforementioned characteristics in platform design helps in laying a solid foundation for the healthy growth of networks. Supporting, e.g., interactivity, connectedness and the creation of ties helps users derive value from network more efficiently, making the network more attractive to new adopters, which in turn can result in a phenomenon called network effect.

In addition, this paper gives practical suggestions on how network effects could be better sustained in multi-sided platforms. In conclusion, platform developers can keep the platform relevant in the long term by, for example, promoting openness and allowing third-party developers to contribute to the platform development, investing in and developing technologies that are relevant to the platform's core function and subsidizing the weaker side of the platform in order to maintain a balanced user base.

Keywords platform design, network effects, social network theory, multi-sided platforms, network growth

Table of Contents

Abstract

| | |
|---|-----------|
| 1 Introduction | 1 |
| 1.1 Research objectives and questions | 2 |
| 1.2 Methods and scope of research | 2 |
| 1.3 Structure of research | 3 |
| 2 Optimizing networks | 3 |
| 2.1 Ways network structure affects value capturing | 3 |
| 2.2 User benefits of having different roles | 7 |
| 2.3 Supporting interactivity through conduct | 9 |
| 3 Achieving network effects | 13 |
| 3.1 What are network effects and how do they occur? | 13 |
| 3.2 Network effects in multi-sided platforms | 15 |
| 3.2.1 Direct network effects in multi-sided platforms | 16 |
| 3.2.2 Indirect network effects in multi-sided platforms | 18 |
| 3.3 Sustaining the growth | 19 |
| 4 Conclusion | 21 |
| 5 Limitations and future research | 23 |
| 6 References | 24 |

1 INTRODUCTION

Groups and users in networked platforms, e.g., Facebook, Amazon and Couchsurfing, can be thought of as nodes where interactions can connect them to different parts of the whole network. Thus, the more possibilities there are to interact, the more the members can gain knowledge and be aware of what is happening in their community. As a result, they can take part in different activities provided by the whole ecosystem. The more relevant possibilities the network provides, the more value there is for a user to gain as it gets easier to explore other users and groups with similar interests and motivations. In order for us to develop practical and user-friendly networks and platforms, we need to take into consideration the fact that it is people who operate in them, which is why we are in need of a better understanding of how and why they take part in the selected networks and platforms in the first place.

The way network success and network effects, i.e. demand- or supply-side economies of scale, are achieved has been seen mainly as a result of the network size by the more classical network theorists (Katz & Shapiro, 1985), who according to the more modern network theorists may have made some hasty generalizations when they have defined network value based mostly on the network size (Afuah, 2013; McIntyre & Srinivasan, 2017), failing to take other important parameters into consideration.

Many successful networked platforms have seen success after their initial focus on a niche group and have grown the network selectively afterwards; for example, Facebook first focused on expanding the service for university students in Ivy League universities and only then, after finding success in a small network, spread the service to other similar segments such as high school students. Instagram first provided a filter tool for photographs and after becoming successful within a small niche of users, extended the service to a community for all mobile photographers. Facebook is also a great example of keeping its platform open for innovation and developers, which is said to be one of its keys to success (Parker & Van Alstyne, 2017). This has helped them focus their resources on the development of their core services. On the contrary, remaining too closed and not allowing interested and relevant stakeholders to participate in the platform development was the demise of the social networking site MySpace (Parker & Van Alstyne, 2017).

1.1 Research objectives and questions

It seems to be of a great importance to form a proper understanding on how networks function at large and how people can derive value from them. Supporting network characteristics that help users derive value—i.e., structure, groups, user roles and conduct—and establishing a valuable ecosystem around a network can help it sustain itself better and to stay relevant to the user in the long run.

Therefore, in this thesis, my goal is to answer the following questions:

- 1. Which network characteristics are relevant in allowing and helping the network user in deriving value from a network?*

I decided to choose the first question since a large number of networked platforms, e.g., MySpace and Orkut, have seen their end even after being the leader in terms of the network size. Some of the recent studies (Afuah, 2013; Boudreau & Jeppesen, 2015; McIntyre & Srinivasan, 2017) have expressed how a number of possibly important parameters are being left in the shadow as the size has become the most celebrated characteristic.

- 2. How can platform developers utilize this knowledge in creating network effects that are more sustainable?*

The second question is essential when thinking of networks from a more strategic point-of-view; how can the network theory and the knowledge about characteristics be better utilized in establishing and developing networked platforms that have the ability to stay relevant for their users in the long term?

1.2 Methods and scope of research

I have used literature review as the main method in this thesis, utilizing some of the most comprehensive literature databases such as Scopus, Web of Science and Google Scholar. The studies that I have cited for this thesis are from several fields of study; strategic management, information systems science, management science, social science and economics.

It was not easy to narrow down the subject of this thesis as there lies a lot of studies from the more mathematical side of networks as well as from information technology. I will

not focus on the mathematical side of networks in this thesis since recent studies (McIntyre & Srinivasan, 2017) have called for the study of more qualitative attributes of networks in the creation of sustained, long-term network effects in platforms.

After familiarizing myself with some studies (Afuah, 2013; Burt, 2004; Burt, 2000; Granovetter, 1973; Hariharan et al., 2016; McIntyre & Srinivasan, 2017), I decided to focus the approach of the thesis more on the intersection of strategic management, economics and social sciences as the studies I left out have not yet found a comprehensive answer to why certain networks and platforms last and find success from the more human perspective.

1.3 Structure of research

This thesis begins with a literature review covering the network theory from the aforementioned perspective (Chapter 2) after which network effects and their emergence will be discussed (Chapter 3). Chapter 2 goes through various characteristics which the studies have found the most important in defining network success, namely structure, conduct, groups and user roles. In Chapter 3, I will explore how network effects occur, what are the different approaches to achieve them and how the network theory discussed in Chapter 2 can be utilized in creating more sustainable network effects. After finishing each Chapter, I will make a concluding hypothesis based on the reviewed literature.

2 OPTIMIZING NETWORKS

2.1 Ways network structure affects value capturing

The amount of different network structures is not limited to a certain number—there exists, for example, different variations of one-, two- and multi-sided networks, networks where a high level of isolation or density is present. More importantly, network structure is rather an emerging trait of a network (Kogut, 2000), which, however, doesn't mean that it couldn't be actively contributed to by developers. Afuah (2013) defines network's structure as “the number of members, the relationships among them, and the

heterogeneity and relative characteristics of members and their relationships”. The most commonly built structures of networks in different platforms can be seen in Figure 1; Figure 1a represents a network where everyone can interact with each other (e.g., the national telephone network), Figure 1b illustrates a two-sided network where members of side 1 can only transact with members from side 2 and vice versa (e.g., a credit card service), Figure 1c shows three subnetworks inside a larger network where nodes can be isolated from each other and the interaction in-between can be restricted (e.g., Facebook groups), and in Figure 1d subnetworks are feebly connected through a link (e.g., different parts of one’s LinkedIn network).

Network structure affects network value in numerous ways (Afuah, 2013; Economides, 1996; Lee et al., 2006; Shriver et al., 2013). First, it affects how easily different interactions happen and transactions can be made between the users. When designing a network, the priority should be on creating a structure that provides every user with the possibility to interact with each other in order to maximize the connections inside the network and thus its value to the user (Afuah, 2013) (See Figures 1 and 2). In a telephone network, for example, allowing the interaction between all of its users in an unrestricted way maximizes the number of possible phone calls made, which also makes it more attractive for new people to start using a phone. However, not all of the networks are optimal for the aforementioned style of interaction; on various social networking sites, e.g. Facebook or LinkedIn, groups’ admins can set restrictions on who can join their group and conversation. Thus, maximizing the amount of interactions is not always the ultimate goal in a network, as the users of different platforms may benefit from certain restrictory features, such as those of Facebook and LinkedIn, that add to the functionality of the network. In addition, in credit card networks cardholders are not meant to interact with each other and as are not merchants with each other either (see Figure 1b, where merchants are on Side 1 and cardholders on Side 2). Consequently, in such two-sided networks, having more members on Side 1 provides more value to members on Side 2 and vice versa (Afuah, 2013). Such transaction feasibility is greatly affected by the network structure, as we can see in Figure 1, which developers can have influence over.

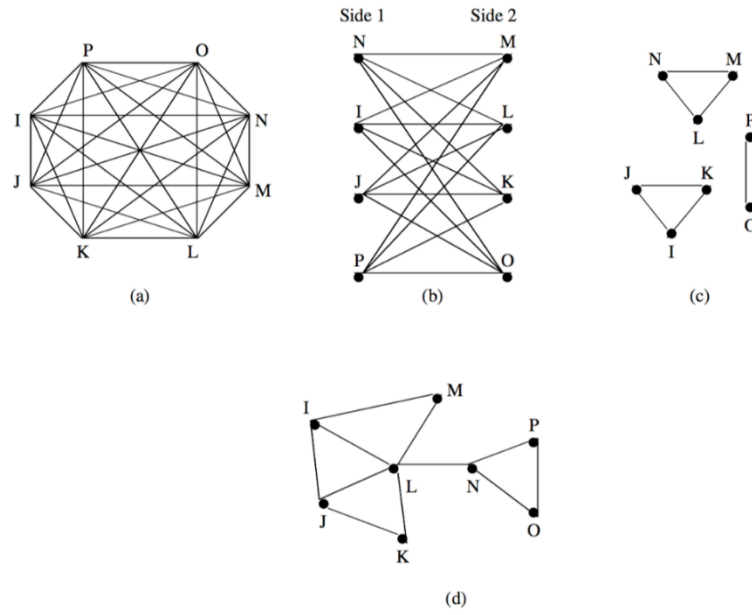


Figure 1. Structure affects users' possibilities to capture value (Afuah, 2013).

Second, the network structure affects how the members can position themselves inside the network and thus how they can capture or add value; the more central one's position, the more they can provide and receive value (Afuah, 2013; Sparrowe et al., 2001) (see Figure 1d; L and N are in a more central position compared to other members), yet some members may be able to reap the benefits off a more non-central position too. A high degree of centrality can allow certain members to act as entrepreneurs of the network, connecting people, items and knowledge (Burt, 2000; Gilsing & Duysters, 2008). This members' possibility to capitalize on centrality and take part in entrepreneur-like activities inside the network is not a zero-sum game however; it brings also non-central members value as they will have a person bridging the network's gaps, i.e., structural holes (see Figure 2b). The entrepreneurial member verifiably brings more diverse information together and thus generates the best ideas and allows non-central members to benefit from this knowledge as well (Burt, 2004; Gilsing & Duysters, 2008).

Third, the way ties are built between individual users and groups inside the network has a great effect on how much they can derive value from the network and therefore also how willing they are to use it or belong to it over a long period of time (Afuah, 2013; Suarez, 2005). Granovetter (1973), a pioneer in social networks, describes the strength of a tie as a result of "the amount of time, the emotional intensity, the intimacy (mutual confiding), and the reciprocal services which characterize the tie", after which he suggests that strong ties are not what make a network sustain; it is actually the amount of weak ties, i.e., infrequent and distant relations (Afuah, 2013), that allows for the

individual to explore and grasp new opportunities and integrates them into communities. Strong ties, i.e. continual and intimate relations (Afuah, 2013), are best for building local cohesion and helping the users to explore and adapt to new products and technologies (Suarez, 2005). However, they are not of great help in keeping distant individuals or communities together (Granovetter, 1973; Reagans & McEvily, 2003). On the contrary, weak links do not help create meaning to network members on the daily basis same way as strong links do, as strong links, i.e., close friends and family, generate trust and reduce individual's chance of misbehaving, but rather in the long term as weak links can bring value to the users in other ways, e.g., by acting as a bridge between distant individuals and communities (Hansen, 1999), and bringing, e.g., unseen job opportunities and information to them this way. As both of the ties have an essential role in allowing the users to derive value from their networks, they should be greatly emphasized in platform development; supporting members in building strong ties helps them accumulate knowledge and locate their needs and supporting them in building weak ties helps them receive and spread knowledge from and to a larger audience and better achieve their needs (Afuah, 2013; Jack, 2005).

In addition, Hansen (1999) demonstrates how the flow of information between network's members can be increased by promoting information codification between ties (see Table 1). Molding information into a certain format and removing unnecessary restrictive functions promotes information accessibility and connectivity inside of a network (Hansen, 1999). This can allow network members to build larger and more useful personal networks. We can see in Table 1 below, that high search benefits and low amount of problems in knowledge retrieval and exploration are related to having information in a codified and independent format. Codifying knowledge is a practice of having knowledge uploaded on a specified page in a specified form (Hansen, 1999). In addition, independent knowledge is independent from its creator and understandable without instructions (Hansen, 1999). In order to utilize this in practice, users can be instructed to write down their accumulated knowledge for others to explore—some examples include public reviews, transaction history, hashtags et cetera. Having features like this makes it more valuable for users to also have weak ties, as new information becomes easier to explore through them. Structural elements also allow for value to be derived from a network and for network effects to occur, which is a phenomenon I will address thoroughly later in this paper.

THE TIE STRENGTH

| KNOWLEDGE | Strong | Weak |
|------------------------------------|---|--|
| Non-codified, Dependent | Search benefits: Low Transfer problems: Moderate | Search benefits: High Transfer problems: High |
| Codified, Independent | Search benefits: Low Transfer problems: Low | Search benefits: High Transfer problems: Low |

Table 1. Search and transfer effects associated with four combinations of knowledge complexity and tie strength (Hansen, 1999).

Hypothesis 1: Network structure affects how interactions and transactions can be made between users, how users can derive value by positioning themselves in a desired way and how ties are built between users. These components altogether allow for value to be derived better from a network by its users.

2.2 User benefits of having different roles

Kumar et al. (2006) distinguish three different member groups in networks; singletons, giant components and the middle region. Singletons, who could also be called loners, are users who have recently joined the network but haven't made a single connection yet with another user. Singletons derive value inside the network from other features of the platform than its users. Giant components form the network's largest group of people who are interconnected with the majority of other users. They could be described as the node L in Figure 1d or any node in Figure 1a. Middle region is considered something between the singletons and giant components; it consists of the communities or small groups inside the network who actively interact with each other but not with the network as a whole. Different kinds of nodes that resemble middle region can be recognized in Figure 1c. In social networking sites, these groups of middle region often possess a collective enthusiasm towards a more niche interest, e.g., paragliding, activism or electric cars. Generally speaking, allowing people to gather up and boundlessly discover interests either familiar or new to them results in greater user satisfaction and commitment (Katona et al., 2011). However, there may arise a need for a person to moderate and guide

the interactions based on the purpose of the network and its users' needs¹ (Mislove et al., 2007).

Members who play a critical role inside these aforementioned groups include initiators and brokers. Brokers can be divided into non-brokers, external brokers and internal brokers (Zhang et al., 2016). Brokers are entrepreneurial members of the network who possess a competitive advantage over other members in terms of knowledge and contact ownership, which helps them bring more value to themselves through greater amount of contacts and trust (Burt, 2000). Initiators can act as either non-brokers or external or internal brokers, depending on their position and connectivity with other parts of the network (Zhang et al., 2016) The difference between internal and external brokers is that internal brokers intertwine groups of individuals together within a platform and external brokers connect initiators between many different platforms. Therefore, platform providers can promote connectivity when growing the platform by focusing on attracting non-opportunistic brokers to join the network (Afuah, 2013).

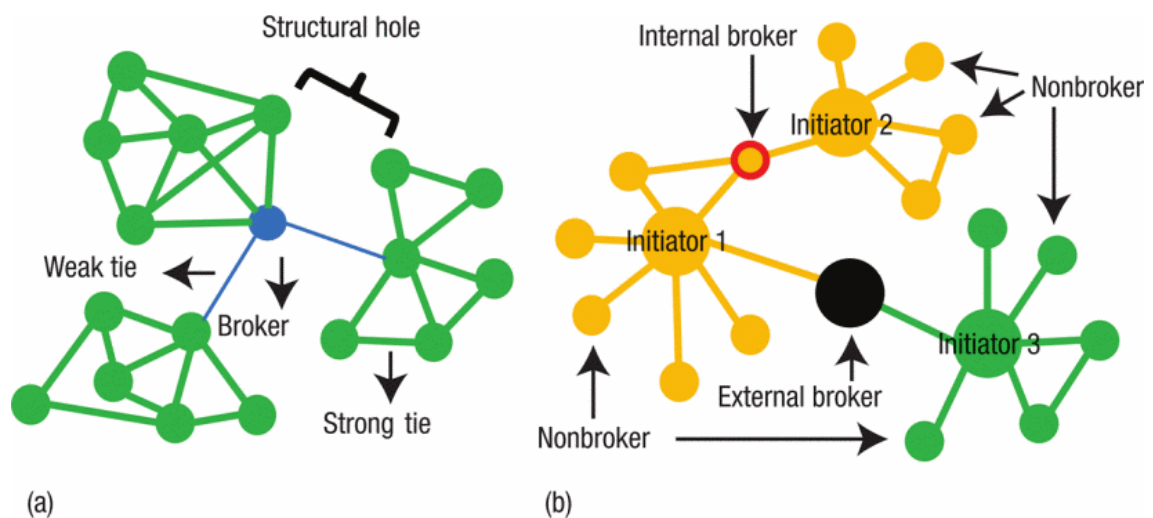


Figure 2. Role of various actors in a social network (Zhang et al., 2016).

These members can have a number of different roles based on the network's structure and conduct (Afuah, 2013). The amount of roles a user has or can have is one of the key determinants in defining the value users can derive from the network. On Airbnb², for

¹ In, e.g., the mobile messaging platform Jodel (<https://jodel-app.com/>) based on a local community and anonymity, users who have received certain amount of positive feedback on their posts can choose to moderate posts and discussions.

² <https://www.airbnb.com/about/about-us>

example, members can act as both tenants and hosts. They also have a responsible role of supervising by providing reviews of tenants and hosts. Same applies to, e.g. the transportation service Uber³, where both sides of the network can have roles not limited only to the core activity, i.e. ordering or driving a car, but are also encouraged to, e.g., giving feedback to the customer and messaging with each other.

Hypothesis 2: The larger the number of relevant roles available to or owned by a user, the larger the amount of value to be derived. In addition, having a role more central can bring more value to the user.

2.3 Supporting interactivity through conduct

Network conduct, i.e., how and what kind of interactions can occur plays a significant role in network's sustainability according to several studies (Afuah, 2013; Chen et al., 2009; Mislove et al., 2007). Afuah (2013) recognizes three separate subcategories of network conduct; opportunistic behavior, reputation effects and trust. Firstly, opportunistic behavior, e.g., black markets or unfair information brokerage, can occur when network members have an option to abuse their position to gain unfair advantage compared to other members (Afuah, 2013; Burt, 2000; Viswanath et al., 2014). Thus, maximizing the utility to the members equally calls for the platform to be designed in a way that decreases such behavior, and one way to achieve such result is to enable other members to gain more collectively from such behavior than the opportunists themselves (Burt, 2000). In practice, this has been achieved by, for example, rewarding users for recognizing and reporting such activity. However, opportunistic behavior can produce benefits in some rare cases, e.g., in some digital products⁴ (Conner & Rumelt, 1991), where piracy has helped create several phenomena among, e.g., game or music hobbyists, but this is apparently an exception rather than the rule. Nevertheless, opportunistic possibilities can act as a source of attraction to their seekers, e.g., entrepreneurs, inside social networks, which as mentioned, can sometimes benefit the network as a whole when regulated in a proper manner.

³ <https://www.uber.com/en-FI/>

⁴ For example, CDs, music albums and games.

Secondly, allowing for reputation effects to occur in networks can greatly help its members to upkeep an appropriate behavior and act in line with the network conduct (Afuah, 2013). Examples of reputation effects that have worked in creating aforementioned behavior on, for example, the marketplace and trade platform eBay include user reviews, rating system, messaging, transaction records and account personalization (Li, 2010). Users also love to contribute to the reputation effects inside the network by giving feedback to the users of the opposing side (Resnick et al., 2006); on eBay, for example, even though giving feedback after each transaction is voluntary, half of the buyers decide to provide the seller with it which indicates a high level of courtesy and respect for the conduct in the network. Thus, it can be considered as a great tool for the users to contribute to the collective healthiness of the network.

Thirdly, trust between members and platform providers can be a deal-breaker for the members to use providers' services (Chen et al., 2009). As the unrestrained flow of information and interactions add to the mutual trust and longevity inside of a network (Hansen, 1999; Shriver et al., 2013; Uzzi, 1997), it seems to be of great importance to the network provider to help its users to interact with each other in order for them to build meaningful connections and thus make the network last longer.

According to Chen et al. (2009) trust can be either mutual—between users, or one-way—towards the platform provider, in a network, of which the significance of mutual trust in building loyalty towards the platform provider has been undervalued for a long time, the research suggests. A good example of finding success through building mutual trust in platforms can be found in the Chinese e-commerce market which eBay entered in 2003 by acquiring Eachnet.com⁵. Eachnet.com emphasized transactions over social interactions between its users—the platform prohibited the use of instant messaging, which turned out to be a huge anticlimax for its users and in reference to an interviewee's comment on why users were disappointed with Eachnet.com's service: "sometimes people want to buy because of impulse" (Ou & Davison, 2009). The lack of this simple feature made it more difficult for the users to locate sellers who were available. This made the buying process inconvenient and ultimately had many of the users switch to the competing Chinese C2C platform, Taobao.com, launched in 2003. As a result of this minor flaw in the platform's design, eBay (China)'s community service was ranked among one of the most unsatisfactory services offered by eBay (China) (Ou & Davison, 2009).

⁵ Eachnet.com is an online customer-to-customer platform in China, started in 1999.

Trust is something that makes people believe their exchange partner will not act in an opportunistic way when interacting, not even to achieve minuscule short-term benefits or advantage (Chiles & McMackin, 1996). Researchers have distinguished four main types of trust in social networks; deterrence-based, calculus-based, institution-based and relational trust (see Table 2) (Rousseau et al., 1998).

Deterrence-based trust is based on the utilitarian idea that people who misbehave or exploit the system or each other will receive sanctions greater than the possible gains derived and thus it is worthwhile to consider other parties and the system as a whole trustworthy. Some examples of sustaining deterrence-based trust include banning users from the service and blocking parties from seeing each other after inappropriate behavior.

Calculus-based trust is built upon the notion that trust comes from rational acts and choices; interactions in general happen due to users' positive intentions and economic transactions benefiting each party involved, which is why it would be counter-intuitive for the party to take part in exploitative behavior. In online auctions, for example, each party has the incentive to act in accordance to the conduct in the long run in order to keep finding and executing the most profitable auctions available.

Institution-based trust can help calculus-based and relational trust form (Rousseau et al., 1998). When there are credible institutions involved in the network, it can help its members build the initial trust needed for them to start building connections and take part in interactions between each other. In online marketplaces, for example, having a trusted agency ensuring consumer protection can help improve the initial trust a good deal.

Lastly, relational trust is a form of trust that is built over time; as network members continuously perform beneficial transactions, the trust between them will grow. Ou et al. (2009) demonstrate this in Table 3 below, where the trust and transaction frequency increase simultaneously. In the beginning, the user who is looking to make a transaction feels indifferent about the seller, if they haven't operated together yet. However, as the amount of successful bilateral transactions increases, so does the satisfaction between both parties.

| TYPE OF TRUST | | | | |
|---------------------------------|---|---|---|--|
| | Deterrence- based | Calculus -based | Institution- based | Relational |
| Basis | Emphasis on utilitarianism. | Emphasis on rational choice. | Emphasis on institutional support. | Emphasis on trust emerging over time. |
| Definition | Parties consider each other trustworthy because of the existing sanctions which reduce the chance of exploitation. | Parties consider each other trustworthy because of their credibility and observable positive intentions. | Institutions present can increase the initial trust, promoting risk taking and trustful behavior in the future. | Parties consider each other trustworthy because of repeated successful transactions. |
| Practical Application(s) | Develop deterrents efficient enough to reduce misbehavior, but also light enough not to scare potential new users away. | Promote transparency and reduce the possibilities of hiding or faking relevant information related to transactions. | Have a credible institution involved when the initial trust needs to be built, and possibly on the long run as well to sustain trust. | Let users interact freely with a preferred partner to generate trust before suggesting other alternatives. |

Table 2. Different forms of trust, compiled and adapted from Rousseau et al., (1998).

| | Arbitrary Scale Value | Verbal Description of Value | Description of the Awareness Driven Trust and Action |
|--------------------------|--------------------------|--|---|
| Seller Insistence | +4 | This is the only seller I would consider buying from. | Long-term trust is stable. Customer loyalty has developed through repeated communication with the seller in the IM. |
| Seller Preference | +3 | This is one of my preferred sellers. | Long-term trust is developed. List the seller in the IM as a friend to keep in touch with. |
| Seller Acceptance | +2 | This is not one of my preferred sellers, but it would be acceptable if my preferred sellers are not available. | The initial trust is built. List the seller in the IM as a friend. |
| Seller Awareness | +1 | I have noticed this seller online, but I have no information about him or her. | The swift trust is created. This seller is in the interested group and to be added in the IM list. |
| Seller Ignorance | 0 | The seller is not online and thus ignored. I know nothing about this seller. | No trust intention. No further contact interest. |
| Seller Rejection | -4 | I would never willingly buy from this seller. | Distrust exists. Blacklist this seller in the IM. |

Table 3. Seller Awareness-Attitude Structure (Ou & Davison, 2009).

Hypothesis 3: Large amount of opportunistic behavior lowers the value of network to its users. A high level of trust promotes the amount of transactions and thus longevity of network. Reputation effects increase users' dependability, trustworthiness and honesty and thus also the possibility for users to derive value.

3 ACHIEVING NETWORK EFFECTS

3.1 What are network effects and how do they occur?

Network effects⁶, also known as demand-side economies of scale, can be seen everywhere around us; we go to the library with the largest offering, we only use the QWERTY keyboard, we go to the mall with the most stores and we are tempted to buy the same software package or application everyone else is using. There is something these aforementioned cases have in common; the operator that has the most users or the largest offering usually wins. Network effects occur in these kinds of situations where a product or a service becomes more valuable to us as the density or the amount of users increases (Parker & Van Alstyne, 2005). Consider a comparison between Facebook and Google+, for example; the user is more likely able to derive more value from Facebook than Google+, as there are more people using the service, the platform has a higher level of general functionality and it also provides other social networking sites (SNSs) with a greater compatibility with its services.

In Table 4 below, Hariharan et al. (2016) show three different types of networks that have a different equation for value formation, which helps us understand why the amount of users is a significant trait in terms of achieving network effects; in broadcast networks, such as television or radio, the value increases linearly with the number of users. In peer to peer networks, e.g., Facebook or Skype, the amount of value increases in proportion to the square as new members join and one- or two-way connections—following or friending, are formed. In group forming networks, e.g., WhatsApp or Slack, the network value can increase exponentially with the size of the network.

⁶ Network effects are sometimes referred to as network externalities.

| | Sarnoff's law | Metcalf's law | Reed's law |
|------------------|---|---|--|
| Value definition | Value of a network is proportional to the number of viewers | Value of a network is proportional to square of number of connected users | Value of group-forming network is proportional to number and ease with which groups form within it |
| Network value | $V \propto n$ | $V \propto n^2$ | $V \propto 2^n$ |
| Network type | Broadcast (Yahoo) | Peer to Peer (Facebook) | Group Forming (WhatsApp or Slack) |

Table 4. Three common laws for assessing the value of communication networks (Hariharan et al., 2016).

In Figure 4 below, I visualize how the network size results in network value growth in different types of networks, where group forming networks seem to have an exponential value growth potential, higher than that of peer to peer and broadcast networks.

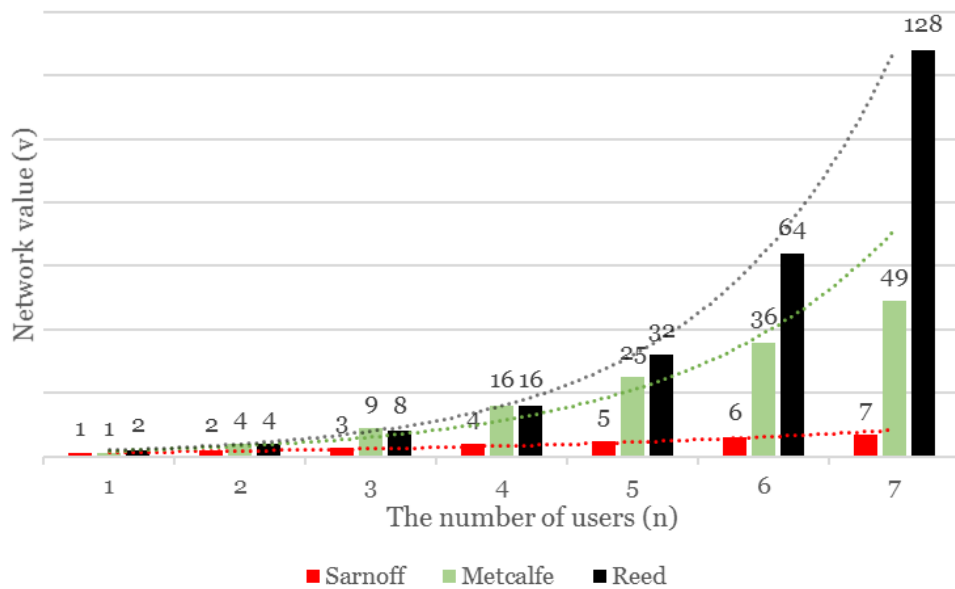


Figure 4. A simplistic visualization of differences in value generation between different network types as defined in Table 4.

Generally speaking, two separate subcategories of network effects can be recognized; direct and indirect. Direct, or the same side, network effects can occur due to the amount of the users using the network, providing users with broader means for communication and interaction among each other inside the network (Boudreau & Jeppesen, 2015; McIntyre & Srinivasan, 2017). Direct network effects are a type of phenomenon that is created by the demand side of the network (Lin & Lu, 2011), i.e., the users. Externalities of the same side can be seen when, for example, a large group of acquaintances or experts

are using similar software or hardware products; with a large community of users it becomes handier to receive support from peers and exchange knowledge regarding the products and thus the prolonged use of them becomes more convenient (Lee et al., 2006).

Indirect, or cross-platform, network effects take place as a result of the complementarity provided by the supply side of the network (Lin & Lu, 2011). In, e.g., the computer hardware market, it usually makes the most sense for the consumer to acquire such computer that has the best compatibility with and access to relevant software programs. Software products can produce similar effects, too. Consider Steam⁷, for example; having the largest online offering in games and gaming-related activities, people are attracted to start using the platform as a comprehensive tool for gaming and gaming-related activities as they will have everything centered in one single platform. Simultaneously, both the platform and the gamers benefit from the rising amount of game developers joining the platform and their game uploads and the game developers can enjoy the large customer base and the high level of concentration of customers Steam is providing them with. The platform also provides great compatibility with other social platforms which results in a remarkable amount of synergy.

3.2 Network effects in multi-sided platforms

I previously discussed what networks and network effects are and how they can be defined. Here I will try to answer the more practical question of network effects; how can they be actually achieved and sustained?

Multi-sided platforms (MSPs) bring two or more sides together who then interact with each other via the platform (Hagiu & Wright, 2015). Some examples of MSPs include a retailer Amazon, who enables third-party sellers to do transactions directly with the customers through its platform; Zappos, whose core is shoe retailing, abandoned its initial business model based on providing a marketplace for a selected group of shoe brands and instead started acting as a platform for shoe retailers and traders in general; and a hospitality platform Couchsurfing, who focuses on bringing travelers together with local hosts and communities. MSPs differ from more traditional, two-sided platforms, in a way that interaction is not limited just to between two parties—usually

⁷ Steam (<http://store.steampowered.com/>) is a digital distribution platform for games, video streaming and social networking services for computer gamers, having 15 million concurrent users in September 2017.

parties can define their own role and fulfill as many different roles simultaneously on the platform as desired (Boudreau & Hagiu, 2008; Hagiu, 2014); acting as, for example, a seller, a buyer, a moderator, a spectator or all of them at the same time. Hagiu (2014) recognizes two defining characteristics of an MSP that make it different from product platforms and resellers; first, each of the sides are customers of the MSP in a relevant way to them and second, the MSP enables the interaction directly between sides, making the middleman unnecessary.

Since network effects occur mainly due to the extra value the network provides its users with (Amit & Zott, 2001), achieving both direct, i.e. same side, and indirect, i.e. cross-platform, network effects in platforms can take place after the network can provide its users with a significant amount of value.

3.2.1 Direct network effects in multi-sided platforms

Platforms can produce direct network effects by increasing their user base. According to the network closure theory (Burt, 2005), a potential user is more likely to join a new network if the users who are inviting the new user to join, are already related to each other (Katona et al., 2011). Thus, opting for a high clustering coefficient⁸ in groups increases the probability of new users joining and committing to the network in the long term. Consequently, MSPs should initially focus on creating a user base where it is natural for its users to have some kind of a connection between each other. For example, Facebook succeeded in doing this when they grew the network by bringing together people who, by a high probability, knew each other from before, which made it easier for them to invite new people to join the network with a higher probability of success. Considering this sensibility of adopting a new technology or a network is crucial in the early phases of the network growth, since the network will begin to grow itself organically after reaching the critical mass⁹ (Shapiro & Varian, 1998)—a network constructed in a way that supports this notion will be more easily grown and administered in the future.

⁸ Clustering coefficient is calculated by dividing the number of links among the neighbors by the maximum number of possible relationships between them (Albert & Barabási, 2002). Thus, the higher the coefficient, the higher the level of connectedness between a selected group of users.

⁹ Critical mass is the size of a user base after which it will become self-sustained and produce further growth by itself.

In Figures 5 and 6 below Kumar et al. (2006) show how the network density, i.e., the ratio of undirected edges to nodes, of Flickr and Yahoo! 360 developed. In both graphs, during the first stage, the density grows rapidly during the first weeks and reaches its initial peak around the week 10, followed by the second stage, where a lengthy dip occurs after which the density finds a gradual increase by organic growth in the third stage.

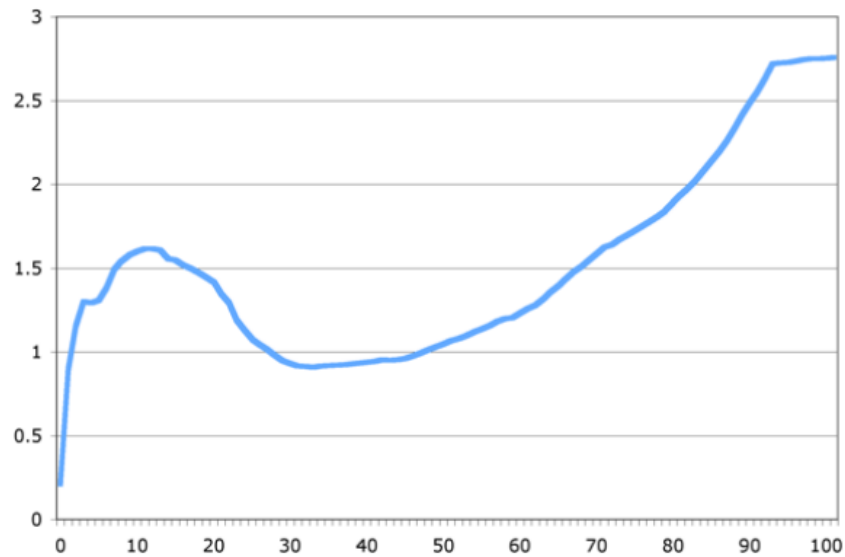


Figure 5. Density of Flickr network, by week (Kumar et al., 2006).

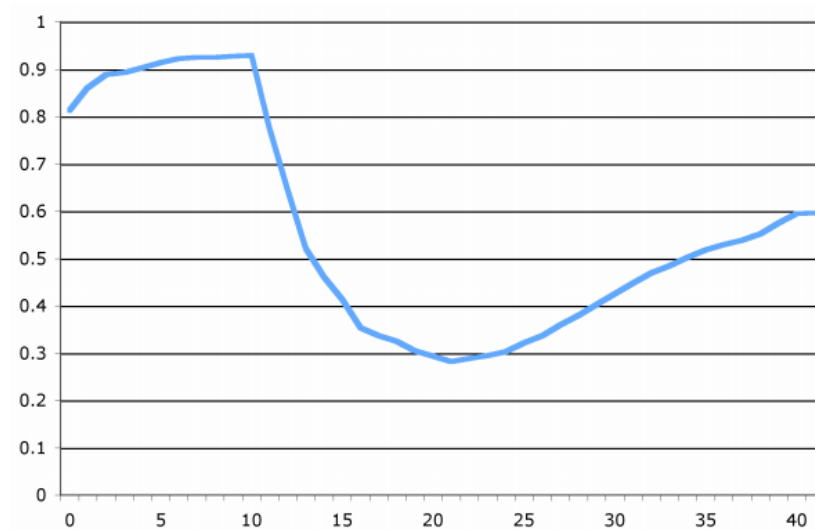


Figure 6. Density of Yahoo! 360 network, by week (Kumar et al., 2006).

There is a lot of enthusiasm among the early users of networks which could be utilized by the developers of MSPs. Usually the relative growth peaks right after the launch of the network, as the initial users are excited about exploring something new and are eager to invite their friends to join the network as well (Kumar et al., 2006).

In the first stage, we can assume that in the cases of both Flickr and Yahoo! 360, it was a small, dense group that started the phenomenon and began to spread the message to other potential users. As time passed, new, disconnected groups emerged. As a result, the network got less dense as a whole as time passed. During the second stage, the network consists mainly of groups that can be assimilated to the middle region—groups, which have a solid form, but are not yet interacting with other parts of the whole network. As a result of the growing density in the third stage, giant components, as described in Chapter 2.2, formed. After reaching this stage, the different parts of network become highly interconnected and organic growth is to be expected without too much extra effort (Shapiro & Varian, 1998).

Hypothesis 4: Focusing on attracting groups of users with a high clustering coefficient will make it easier to attract even more users to the platform in the future, resulting in direct network effects.

3.2.2 Indirect network effects in multi-sided platforms

Allowing for indirect, i.e., cross-platform, network effects to occur in MSPs is essential for their sustainability. As described earlier in Chapter 3.1, indirect network effects occur as a result of the rising of complementary products (Lin & Lu, 2011). For example, it is highly beneficial to people to choose Windows operating system, since there lies a great amount of popular products and services that it supports, e.g., spreadsheet software, movie-editing software, games et cetera. Consequently, in order for platform owners to support the occurrence of indirect network effects in their platforms, they should focus on allowing the open development of these products and service.

Apple, one of the world's largest platform companies, was on the brink of going bankrupt, when its technology remained closed for too long (West, 2003). Same happened to MySpace more recently, which ended up losing its focus by developing everything for everyone by themselves (Parker & Van Alstyne, 2017). Thus, having a platform open enough will help the platform to be contributed to by third-party developers and thus the platform will keep up better with the pace of users' rising demands (Parker & Van Alstyne, 2017). Making the technology open to third-party developers has, obviously, both pros and cons; it can help build momentum behind the platform with increasing speed in development, but it can also risk its creator's ability to control the platform (Boudreau, 2010).

Another way to increase the occurrence of indirect network effects is to advance compatibility between platforms (Matutes & Regibeau, 1992), as the high level of compatibility results in overall efficiency, making it easier for users to adopt new services (Farrell & Klemperer, 2007). A platform that is highly compatible with other platforms is more likely to provide its users with larger amount of value than those that are not (McIntyre & Subramaniam, 2009). It should be noted, however, that platforms with a large installed base tend to resist compatibility with small rivals (Farrell & Klemperer, 2007). Thus, the decision to collaborate with a selected platform should be thoroughly evaluated.

In some cases, users may ponder whether a single platform provides them everything they need related to a selected area of interest. They have to decide whether they want to use a single platform or multiple platforms for their needs related to, e.g., social interaction; some get their needs fulfilled by using just Facebook, while others need to use Instagram, Twitter and LinkedIn as well. This is called single- or multi-homing (Armstrong, 2006; Caillaud & Jullien, 2003; Farrell & Klemperer, 2007); an observation on how many platforms the user is using to derive the needed value. Single-homing occurs in, e.g., credit card platforms, when the user has the membership of only one service provider (Rochet & Tirole, 2004). On the other hand, multi-homing occurs when, in the aforementioned situation, the user has the membership of multiple service providers. When trying to achieve indirect network effects, it is important to recognize how and what kind of value the network in hand is providing its users with and if it was be possible to have the features they need assembled in one platform to ease the process of value capturing. Establishing possibilities for different networks to be integrated with each other better among the same area of interest allows for win-win-situations to occur for the platforms involved, where the longevity of all of them becomes an interest to the user as well.

Hypothesis 5: Platform openness can help build momentum for the platform, attracting even more third-party developers to create complementary products and resulting in indirect network effects.

3.3 Sustaining the growth

Network effects tend to occur when the platform has gained an advantage in terms of the size of its user base and when the network characteristics favor constant value capturing.

But how can this effect be sustained in the long term? Generally, the literature on networks and networked industries has found three main elements that are relevant to the management of value capturing in networks and which advance the occurrence and sustainability of network effects: users' expectations, users' coordination and compatibility with other networks (Fuentelsaz et al., 2015; Katz & Shapiro, 1994). In the context of MSPs, this means that investing continuously in these three elements, keeps the platform relevant to the user and allows the continuous value capturing.

Users tend to favor products and services offered by an operator with a larger installed base (Birke & Swann, 2006). Thus, when choosing a platform, users expect that it will be or become the dominant actor in the industry (Eisenmann, 2006). As a result, network owners are incentivized to communicate a message to the current and potential users that it will be the best option to them in the future as well. Platform developers can show long-term commitment to the platform development in order to meet or exceed users' expectations (Hariharan et al., 2016). By investing in and developing technologies that are relevant to the platform and its core function, the platform provider can send a signal to its users that it will remain more relevant to them than other MSPs in the future. Increasing the network size may not always be the answer to satisfy user needs per se, as in social networks users are not usually as interested in the aggregate network as they are in their relevant network (Boudreau & Hagiu, 2008). Thus, developing mechanisms that create a better environment for users to sustain and develop ties meaningful to them will help the network remain relevant to them in the long run.

In order to advance compatibility with other networks, developers of MSPs can try to make better use of the existing network and increase its relevance to other stakeholders as well, instead of hogging the network to themselves (Baldwin & Woodard, 2008; Hariharan et al., 2016; Katz & Shapiro, 1985). It comes as no surprise, why so many successful platforms have a high level of compatibility with other platforms. For example, Facebook helps the music streaming platform Spotify by providing them with a convenient identification and exploration of new music based on shared interests with their Facebook friends. This interconnectedness advances the ease and speed of use which is often the user's expectation in today's platforms. Facebook's success has been said to be a result of the openness towards third-party developers and the way Facebook allows others to participate in the process of innovating and developing new features (Parker & Van Alstyne, 2017), while alternatively, the founder of MySpace stated, that the service's demise was to remain too closed for too long and the way they tried to develop all of the features their users were requesting by themselves, made them ultimately lose their focus on the core of the service they were meant to develop in the first place (Parker & Van Alstyne, 2017).

On the other hand, the platform owner must remain wary of giving too much power to complementors (Baldwin & Woodard, 2008). Allowing complementors to integrate their services on an unnecessarily high level might put the platform ownership at risk and lead to incremental dilution of the original platform owner's relevance. For example, Microsoft has been successful in taking over some of the platform ownership from Android by making its products a standard in Android devices and services. By allowing this to happen, Android might have significantly reduced its relevance to the developer community as the major inclusion of Microsoft reduces their freedom to create services and products on Android.

Hypothesis 6: Network effects can be sustained by communicating commitment to platform to stakeholders, opening the platform and its user base to third-party developers and subsidizing the different sides of the platform to keep the demand satisfied.

4 CONCLUSION

In this thesis, I have studied how various network characteristics affect network users' possibility to derive value from networks. In addition, I present how network effects occur and suggest how the phenomenon can be better sustained in multi-sided platforms. In the second chapter, I describe different important network characteristics based on the studied literature, namely structure, conduct, groups, roles and their role in allowing users' value capturing. In the third chapter I describe the importance of these characteristics in the creation of sustainable network effects in multi-sided platforms by showing evidence from literature.

The way various network characteristics allow network users' value capturing can vary between networks, but the mentioned characteristics all still play a significant role in that. While the network size has for long been the most celebrated trait of a network, it does not seem to explain the network value and possibilities for value capturing alone. In general, network size does explain the value that the network can provide its users with, as presented in both Table 4 and Figure 4, but the claim that it would make a network successful alone, is too bold to be made. Developers of MSPs can increase the possibilities for value capturing by developing a suitable network structure that allows users to

position themselves in a desired way and form both strong and weak ties in order to derive the needed value.

Even though growth is, understandably, a relevant strategic goal of many platforms, many important network characteristics can be and have been left in the shadow in the growth process. To support the sustained growth of a multi-sided platform, it is essential to consider other network characteristics that support the fulfilment of users' needs well.

In conclusion, I have listed the hypotheses made in this thesis in Tables 5 and 6 below. In addition, I have added suggestions how the studied characteristics could be taken into consideration in platform development and creation of sustainable network effects.

NETWORK THEORY

| Network Characteristic | Hypothesis | Practical application(s) |
|-------------------------|--|--|
| Structure | H1: Network structure affects how interactions and transactions can be made between users, how users can derive value by positioning themselves in a desired way and how ties are built between users. These components altogether allow for value to be derived better from a network by its users. | Build a structure that maximizes the amount of possible transactions between users. Allowing users to have a healthy ratio of both strong and weak ties helps users capture value and the network to be sustained. |
| Roles and groups | H2: The larger the number of relevant roles available to or owned by a user, the larger the amount of value to be derived. In addition, having a role more central can bring more value to the user. | Do not limit the number of roles possessed by a user. When growing a network, focus on attracting non-opportunistic users who have a tendency to play a central role. |
| Conduct | H3: Large amount of opportunistic behavior lowers the value of network to its users. A high level of trust promotes the amount of transactions and thus longevity of network. Reputation effects increase users' dependability, trustworthiness and honesty and thus also the possibility for users to derive value. | Minimize chances for opportunistic behavior in network. Create mechanisms that promote emergence of trust and build trustworthiness, honesty and dependability in network. |

Table 5. Hypotheses and practical applications of the thesis regarding the network theory.

NETWORK EFFECTS IN MULTI-SIDED PLATFORMS

| Network effect type | Hypothesis | Practical application(s) |
|---------------------|--|--|
| Direct | H4: Focusing on attracting groups of users with a high clustering coefficient will make it easier to attract even more users to the platform in the future, resulting in direct network effects. | Start growing the user base by focusing on groups of people in narrow area who have the possibility of having at least a feeble connection. |
| Indirect | H5: Platform openness can help build momentum for the platform, attracting even more third-party developers to create complementary products and resulting in indirect network effects. | Support compatibility and advance openness in platform creation in to advance the ease of platform development and adoption. |
| Sustained | H6: Network effects can be sustained by communicating commitment to platform to stakeholders, opening the platform and its user base to third-party developers and subsidizing the different sides of the platform to keep the demand satisfied. | Be proactive in creating possibilities for third parties to contribute to and utilize the platform, investing in technologies relevant in enabling value capturing and subsidizing the weaker sides of the platform. |

Table 6. Hypotheses and practical applications of the thesis regarding the creation of sustainable network effects in multi-sided platforms.

5 LIMITATIONS AND FUTURE RESEARCH

This thesis provides a general overview of the relevant network characteristics and their role in making value capturing possible for network users. Having a narrow scope in this thesis, however, leaves a lot of room for questions—e.g., how open should the platform remain for third-party contributors for the platform’s original creator to retain its ownership? How do platform developers recognize their core features, when outsourcing additional features to third-party contributors? How should the network characteristics be weighted and given importance to when designing networks in different platforms and what is their role in the occurrence of network effects? In general, more empirical research regarding the role of various network characteristics in supporting sustained growth of networks is still required to form a comprehensive and up-to-date understanding of how networks, and more precisely, multi-sided platforms succeed.

6 REFERENCES

- Afuah, A. (2013). Are network effects really all about size? the role of structure and conduct. *Strategic Management Journal*, 34(3), 257-273. doi:10.1002/smj.2013
- Albert, R., & Barabási, A. (2002). Statistical mechanics of complex networks. *Reviews of Modern Physics*, 74(1), 47.
- Amit, R., & Zott, C. (2001). Value creation in E-business. *Strategic Management Journal*, 22(6), 493-520.
- Armstrong, M. (2006). Competition in two-sided markets. *The Rand Journal of Economics*, 37(3), 668-691.
- Baldwin, C. Y., & Woodard, C. J. (2008). The architecture of platforms: A unified view.
- Birke, D., & Swann, G. M. P. (2006). Network effects and the choice of mobile phone operator. *Journal of Evolutionary Economics*, 16(1-2), 65-84. doi:<http://dx.doi.org/10.1007/s00191-005-0001-5>
- Boudreau, K. (2010). Open platform strategies and innovation: Granting access vs. devolving control. *Management Science*, 56(10), 1849-1872.
- Boudreau, K., & Hagiu, A. (2008). Platform rules: Multi-sided platforms as regulators.
- Boudreau, K. J., & Jeppesen, L. B. (2015). Unpaid crowd complementors: The platform network effect mirage. *Strategic Management Journal*, 36(12), 1761-1777. doi:10.1002/smj.2324
- Burt, R. S. (2004). Structural holes and good ideas. *American Journal of Sociology*, 110(2), 349-399.
- Burt, R. S. (2005). Brokerage and closure.
- Burt, R. S. (2000). *The network structure of social capital* doi:[https://doi.org/10.1016/S0191-3085\(00\)22009-1](https://doi.org/10.1016/S0191-3085(00)22009-1)
- Caillaud, B., & Jullien, B. (2003). Chicken & egg: Competition among intermediation service providers. *RAND Journal of Economics*, , 309-328.
- Chen, J., Zhang, C., & Xu, Y. (2009). The role of mutual trust in building members' loyalty to a C2C platform provider. *International Journal of Electronic Commerce*, 14(1), 147-171. doi:10.2753/JEC1086-4415140105
- Chiles, T. H., & McMackin, J. F. (1996). Integrating variable risk preferences, trust, and transaction cost economics. *The Academy of Management Review*, 21(1), 73-99. doi:10.2307/258630

- Conner, K. R., & Rumelt, R. P. (1991). Software piracy: An analysis of protection strategies. *Management Science*, 37(2), 125-139. doi:10.1287/mnsc.37.2.125
- Economides, N. (1996). *The economics of networks* doi:[https://doi.org/10.1016/0167-7187\(96\)01015-6](https://doi.org/10.1016/0167-7187(96)01015-6)
- Eisenmann, T. R. (2006). Internet companies' growth strategies: Determinants of investment intensity and long-term performance. *Strategic Management Journal*, 27(12), 1183-1204.
- Farrell, J., & Klemperer, P. (2007). Coordination and lock-in: Competition with switching costs and network effects. *Handbook of Industrial Organization*, 3, 1967-2072.
- Fuentelsaz, L., Garrido, E., & Maicas, J. P. (2015). A strategic approach to network value in network industries. *Journal of Management*, 41(3), 864-892.
- Gilsing, V. A., & Duysters, G. (2008). Understanding novelty creation in exploration networks—structural and relational embeddedness jointly considered. *Technovation*, 28(10), 693-708.
- Granovetter, M. S. (1973). The strength of weak ties. *American Journal of Sociology*, 78(6), 1360-1380.
- Hagiu, A. (2014). Strategic decisions for multisided platforms. *MIT Sloan Management Review*, 55(2), 71.
- Hagiu, A., & Wright, J. (2015). Multi-sided platforms. *International Journal of Industrial Organization*, 43, 162-174.
- Hansen, M. T. (1999). The search-transfer problem: The role of weak ties in sharing knowledge across organization subunits. *Administrative Science Quarterly*, 44(1), 82-111.
- Hariharan, A., Jordan, J. & Chokshi, S. (2016). All about network effects. Retrieved from <https://a16z.com/2016/03/07/all-about-network-effects/>
- Jack, S. L. (2005). The role, use and activation of strong and weak network ties: A qualitative analysis*. *Journal of Management Studies*, 42(6), 1233-1259. doi:10.1111/j.1467-6486.2005.00540.x
- Katona, Z., Zubcsek, P. P., & Sarvary, M. (2011). Network effects and personal influences: The diffusion of an online social network. *Journal of Marketing Research*, 48(3), 425-443. doi:10.1509/jmkr.48.3.425
- Katz, M. L., & Shapiro, C. (1994). Systems competition and network effects. *The Journal of Economic Perspectives*, 8(2), 93-115.
- Katz, M. L., & Shapiro, C. (1985). Network externalities, competition, and compatibility. *The American Economic Review*, 75(3), 424-440.
- Kogut, B. (2000). The network as knowledge: Generative rules and the emergence of structure. *Strategic Management Journal*, 21(3), 405-425.

- Kumar, R., Novak, J., & Tomkins, A. (2006). Structure and evolution of online social networks. *Proceedings of the ACM SIGKDD International Conference on Knowledge Discovery and Data Mining*, , 2006 611-617.
- Lee, E., Lee, J., & Lee, J. (2006). Reconsideration of the winner-take-all hypothesis: Complex networks and local bias. *Management Science*, 52(12), 1838-1848. doi:10.1287/mnsc.1060.0571
- Li, L. I. (2010). Reputation, trust, and rebates: How online auction markets can improve their feedback mechanisms. *Journal of Economics & Management Strategy*, 19(2), 303-331.
- Lin, K., & Lu, H. (2011). Why people use social networking sites: An empirical study integrating network externalities and motivation theory. *Computers in Human Behavior*, 27(3), 1152-1161. doi:10.1016/j.chb.2010.12.009
- Matutes, C., & Regibeau, P. (1992). Compatibility and bundling of complementary goods in a duopoly. *The Journal of Industrial Economics*, , 37-54.
- McIntyre, D. P., & Srinivasan, A. (2017). Networks, platforms, and strategy: Emerging views and next steps. *Strategic Management Journal*, 38(1), 141-160.
- McIntyre, D. P., & Subramaniam, M. (2009). Strategy in network industries: A review and research agenda. *Journal of Management*, 35(6), 1494-1517.
- Mislove, A., Marcon, M., Gummadi, K. P., Druschel, P., & Bhattacharjee, B. (2007). Measurement and analysis of online social networks. *Proceedings of the 7th ACM SIGCOMM Conference on Internet Measurement*, 29-42.
- Ou, C. X., & Davison, R. M. (2009). Technical opinion why eBay lost to TaoBao in china: The glocal advantage. *Communications of the ACM*, 52(1), 145-148.
- Parker, G., & Van Alstyne, M. (2005). Two-sided network effects: A theory of information product design. *Management Science*, 51(10), 1494-1504. doi:10.1287/mnsc.1050.0400
- Parker, G., & Van Alstyne, M. (2017). Innovation, openness, and platform control. *Management Science*,
- Reagans, R., & McEvily, B. (2003). Network structure and knowledge transfer: The effects of cohesion and range. *Administrative Science Quarterly*, 48(2), 240-267.
- Resnick, P., Zeckhauser, R., Swanson, J., & Lockwood, K. (2006). The value of reputation on eBay: A controlled experiment. *Experimental Economics*, 9(2), 79-101. doi:<http://dx.doi.org/10.1007/s10683-006-4309-2>
- Rochet, J., & Tirole, J. (2004). Two-sided markets: An overview. *Institut d'Economie Industrielle Working Paper*,

- Rousseau, D. M., Sitkin, S. B., Burt, R. S., & Camerer, C. (1998). Introduction to special topic forum: Not so different after all: A cross-discipline view of trust. *The Academy of Management Review*, 23(3), 393-404.
- Shapiro, C., & Varian, H. R. (1998). *Information rules: A strategic guide to the network economy* Harvard Business Press.
- Shriver, S. K., Nair, H. S., & Hofstetter, R. (2013). Social ties and user-generated content: Evidence from an online social network. *Management Science*, 59(6), 1425-1443.
- Sparrowe, R. T., Liden, R. C., Wayne, S. J., & Kraimer, M. L. (2001). Social networks and the performance of individuals and groups. *Academy of Management Journal*, 44(2), 316-325.
- Suarez, F. F. (2005). Network effects revisited: The role of strong ties in technology selection. *The Academy of Management Journal*, 48(4), 710-720. doi:10.2307/20159688
- Uzzi, B. (1997). Social structure and competition in interfirm networks: The paradox of embeddedness. *Administrative Science Quarterly*, , 35-67.
- Viswanath, B., Bashir, M. A., Crovella, M., Guha, S., Gummadi, K. P., Krishnamurthy, B., & Mislove, A. (2014). Towards detecting anomalous user behavior in online social networks. *USENIX Security Symposium*, 223-238.
- West, J. (2003). How open is open enough?: Melding proprietary and open source platform strategies. *Research Policy*, 32(7), 1259-1285.
- Zhang, Q., Zeng, D. D., Wang, F., Breiger, R., & Hendler, J. A. (2016). Brokers or bridges? exploring structural holes in a crowdsourcing system. *Computer*, 49(6), 56-64.